Multi-Scale Model-Driven Sampling with Autonomous Systems At A National Littoral Laboratory: Turbulence Characterization from an AUV

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LONG-TERM GOAL

The long term goal of this research is to utilize turbulence measurements obtained from small Autonomous Underwater Vehicle (AUV) based sensors as the subgrid characterization tool in coastal ocean observation/prediction networks.

OBJECTIVES

The objective of this research is to use AUV-based turbulence measurements to quantify mixing in shallow water physical process studies (upwelling regions, fronts. boundary layers) within the context of the LEO-15 based National Ocean Partnership Program (NOPP) coupled ocean observation/modeling system This includes estimating mixing levels, identifying regions of enhanced mixing, determining the horizontal spatial scale of mixing events, defining the role of boundary layers, and parameterizing results for coastal predictive model testing studies of subgrid scale processes.

APPROACH

The initial stage of the approach is to integrate an optimum turbulence sensor suite into a small, logistically simple, AUV, with input from the ocean turbulence and modeling communities. The next stage is to establish this small AUV as a viable platform for coastal turbulence research. Towards this end, horizontals profiles of estimated dissipation rate, temperature microstructure, 3-dimensional small scale velocity, finescale vertical shear of horizontal current, and stratification are obtained in the coastal environment.

Subsequently, mixing is studied in the context of the multi-scale measurements surrounding the NOPP LEO-15 node site in the Mid-Atlantic Bight, during the summer upwelling season. Sampling is done adaptively using input from the Rutgers University continental shelf model SCRUM (Song and Haidvogel, 1994). The sensor suite enables estimates of eddy diffusivity profile (Gargett and Moum (1995), eddy viscosity profile (using the truncated TKE equation), Richardson numbers, and fluxes [using the correlation technique]. These data enable us to evaluate turbulence closure schemes associated with subgrid mixing processes as parameterized by 3 different surface boundary layer submodels in SCRUM, the coastal circulation model

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WORK COMPLETED

The REMUS AUV has been instumented with a turbulence sensor package, which has been cantilevered off the bow or integrated into the hull. (Levine and Lueck, 1999) (Fig. 1). Sensors include two shear probes, an ultra-fast thermistor, an upward and downward looking ADCP, two CTDs, and an ADV-O.

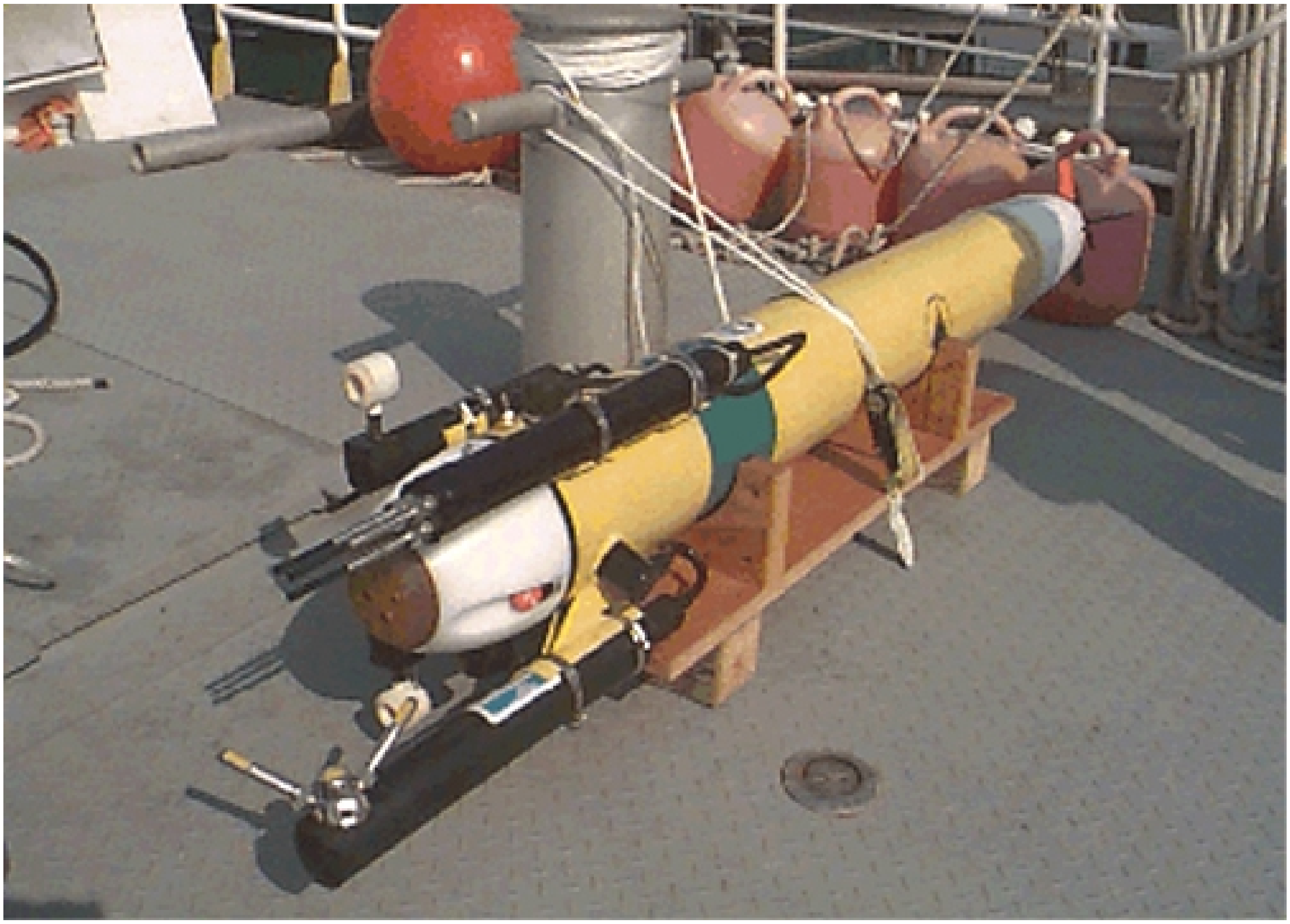

Fig 1. The REMUS AUV instrumented with turbulence sensors

Utilizing this system, scientific studies of the Ocean Boundary Layer (OBL) during an upwelling event were conducted near the Rutgers University LEO-15 site on the inner continental shelf off New Jersey during July 1998. In the field experiment, high quality data were obtained from all sensors, and a turbulence characterization in various components of the upwelling system has been obtained.

RESULTS

Model-based adaptive sampling, updated with synoptic information from the other platforms, was used to deploy the AUV was along trajectories through components of the Leo-15 upwelling region, including the upwelling gyre and offshore jet. Model predictions include assimilated data from the wide variety of sampling platforms which characterize larger scale structures on the continental shelf.

Results indicate that the modified REMUS AUV was a viable platform for turbulence data acquisition in the coastal ocean. Analysis of the shear probe data indicate that after platform noise removal, using the techniques of Levine and Lueck (1999), the shear autospectra agree with the Nasmyth "universal spectrum" (Oakey, 1982) out to wavenumbers close to the physical size of the sensing tip of the probes.

For the case of fully developed upwelling , an example of the upwelling gyre center and offshore jet turbulence characterization estimation is shown in Fig 2. For a 5 m depth transit, time series of mixing parameter estimates primarily show dissipation rates of 10^{-7} to 10^{-6} W kg $^{-1}$, eddy diffusivities of 10^{-5} to 10^{-4} m^2 s^{-1}, eddy viscosities of 10^{-4} to 10^{-3} m^2 s^{-1}, and Richardson numbers of 10^0 to 10^1.

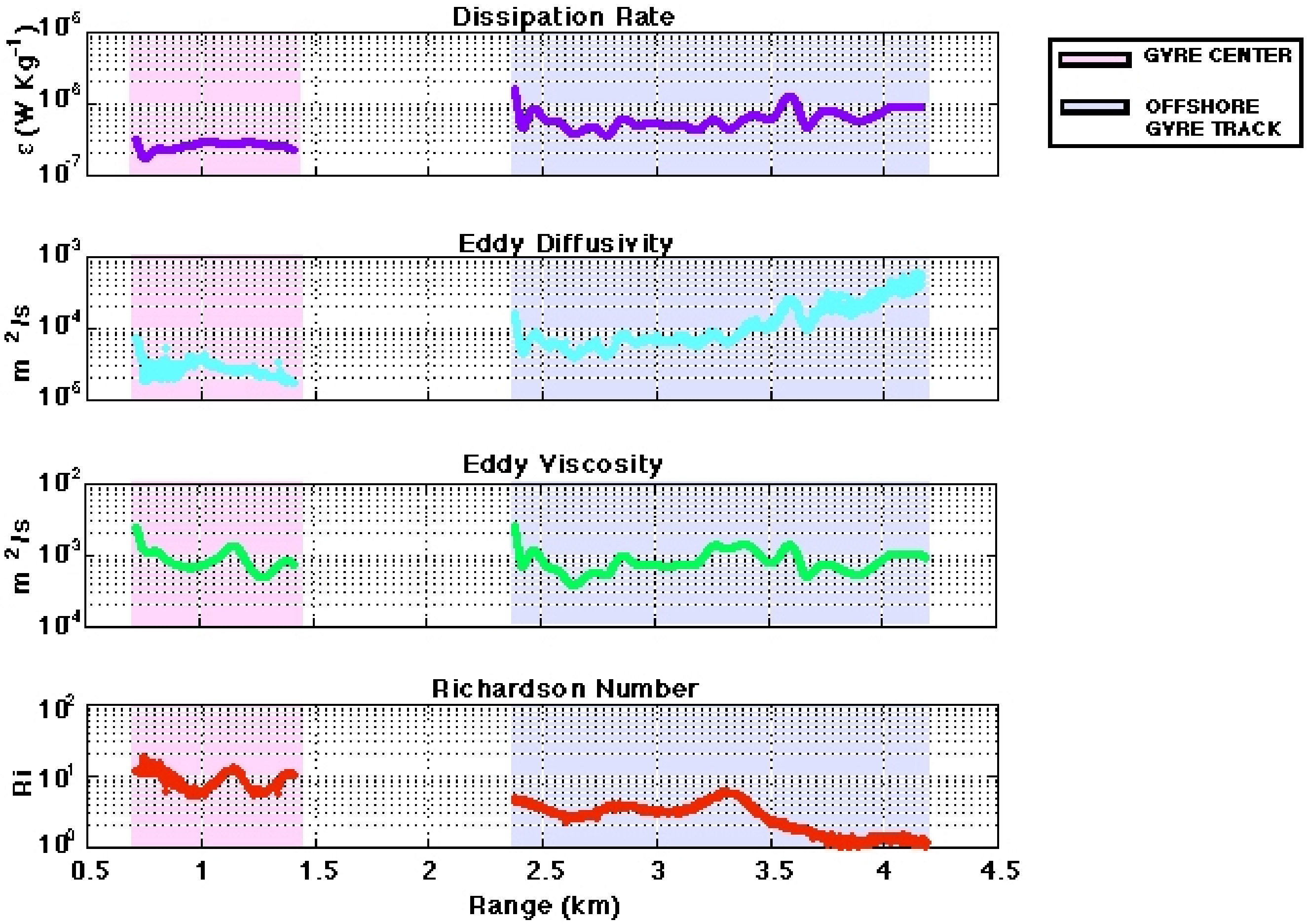

Fig 2. Mixing parameters from LEO-15 upwelling region, July 1998

IMPACT/APPLICATION

The AUV-based turbulence measurements provide a unique horizontal profiling view of the variability of the mixing environment that cannot be obtained by more conventionally sampling measurements, and this approach can be further exploited in yo-yoed horizontal sections. These techniques are invaluable in upwelling process studies in which competing turbulence closure model alternatives are

testing in SCRUM to parameterize subgrid processes. Competing OBL alternatives include those of Mellor-Yamada (1974) Large et al. (1994), and Price et al. (1986). Features such as the evolution of the upwelling front can be tested.

TRANSITIONS

Our AUV sensor technologies, hardware and software, are being considered for inclusion as tactical oceanography payloads for the Manta UUV Initiative

RELATED PROJECTS

Follow-on studies with the Rutgers group were conducted in 1999 under separate NOPP support. Also, my AUV-based turbulence measurement system is being utilized in NOPP studies with the Harvard led LOOPS project, for which measurements were also made in Cape Cod Bay during September 1998. The system is also being utilized in NOPP FRONT studies on the New England continental shelf during 1999-2001.

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